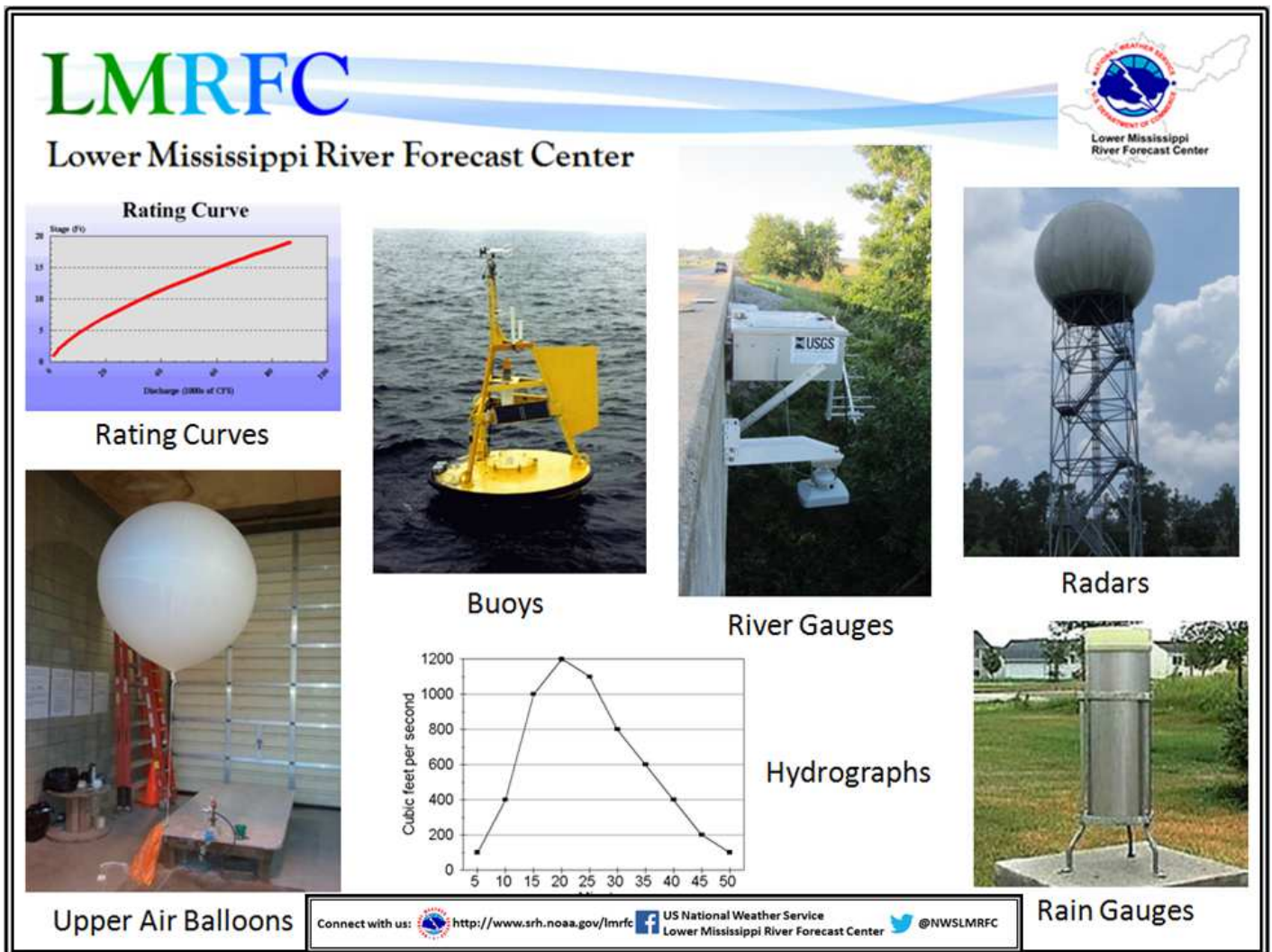


## May Monthly Educational Module

### “The Lower Mississippi River Forecast Center’s Forecasting Tools”


#### Day 1

Welcome to the Lower Mississippi River Forecast Center’s 5th Monthly Educational Module! This module highlights many of the tools we use on a daily basis to get you the most accurate and up-to-date river and precipitation forecasts! If you want a sneak peak at SOME of the tools we use in our daily operations, check out the graphic below.



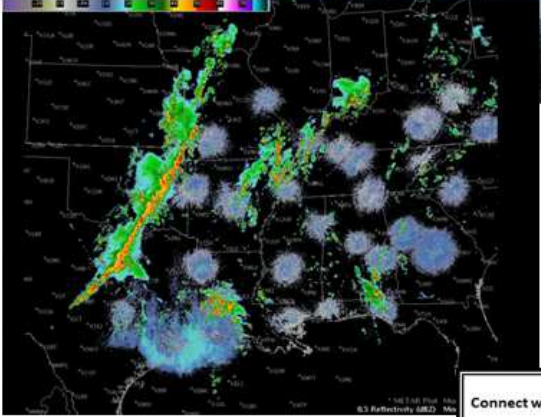

## Day 2

Our first tool is the radar! The Lower Mississippi River Forecast Center uses radars on a daily basis in order to know where precipitation is occurring and how much. This information is then put into our hydrologic models to see how rivers in the LMRFC area are going to respond from the precipitation. If you want to learn all about radars and their importance in the LMRFC's daily operations, check out the graphic below.



Lower Mississippi River Forecast Center

# Radars






Radars send out signals to detect objects moving in the atmosphere. These signals bounce off of objects and return to the radar. This creates raw radar data. These objects include precipitation like rain, snow, sleet, and freezing rain, as well birds, planes, helicopters, and other objects in the sky. Any objects other than precipitation are referred to as anomalous propagation.

Radar data are interpreted by algorithms (equations) to differentiate precipitation from other objects, as well as to determine how much precipitation was detected. These data are then mosaicked (combined) together to form a map of precipitation values and its movement (pictured bottom left).

There are different radar scans for different types of weather going on. This determines how fast or slow the radar sends out beams to detect objects, as well as how many beams are sent. When there is no precipitation in the area, Clear-Air Mode is used. This has less, slower scans. When there is precipitation, a variety of Precipitation Modes are used depending on the intensity of the precipitation. Precipitation Modes have more, faster scans than Clear-Air Mode.

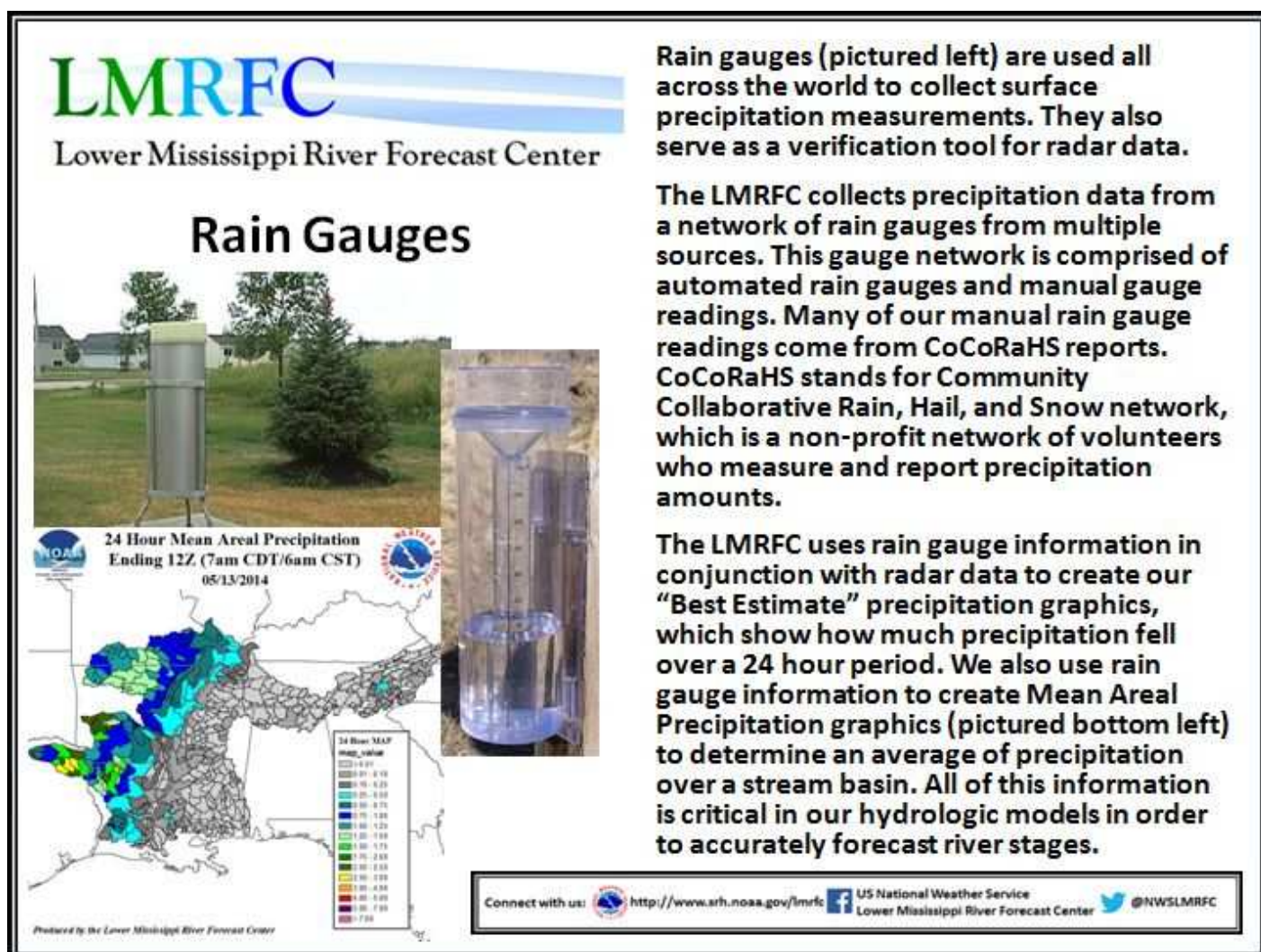
There are different types of radars. The most common radars that provide data for the NWS are WSR-88Ds and TDWRs. WSR-88D are known as Weather Surveillance Radars that were established in 1988 and are Doppler radars. These are owned and operated by the National Weather Service. TDWRs are known as Terminal Doppler Weather Radars and are most used at airports. There are 26 NWS WSR-88D Radars in the LMRFC area.

Radar data are beneficial in our daily operations as they provide timely precipitation estimates that go into our hydrologic models.

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## Day 3

Let's continue highlighting important LMRFC tools by talking about rain gauges. Rain gauges are crucial in determining how much precipitation is on the ground, so we can see how that precipitation will affect river levels in the LMRFC area. If you would like to learn more about rain gauges and their importance in the LMRFC's daily operations, check out the graphic below.

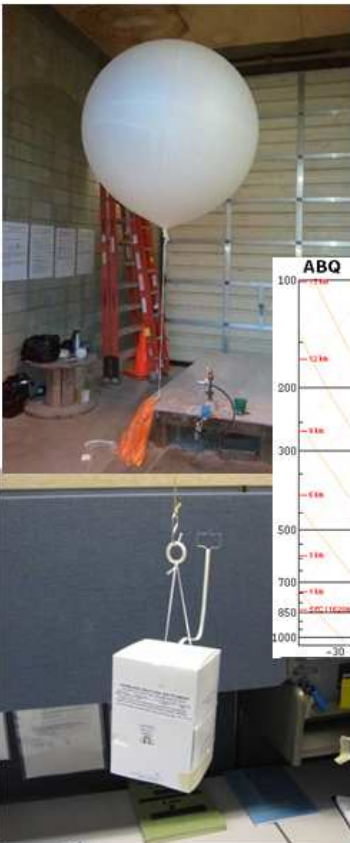


## Day 4

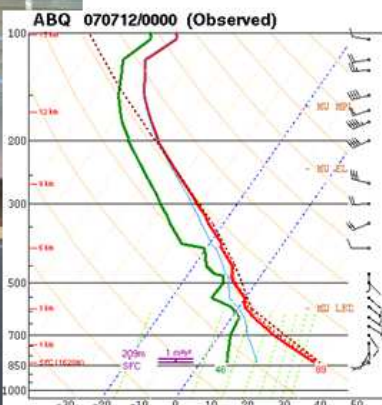
Have you ever wanted to know where the weather models get their data? Well...Our next tool is one way! Next, we are covering Upper Air Balloons! Upper air balloons carry instruments called radiosondes which collect upper air observations that are vital in weather forecasting. All of the data collected is compiled, archived, and used in weather models for short term and long term forecasting. If you would like to learn more about upper air balloons and radiosondes, check out the graphic below!



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Upper Air  
Balloons



ABQ 070712/0000 (Observed)

Since the late 1930s, the National Weather Service has been taking upper air observations with air balloons and radiosondes to collect upper air data for weather analysis, forecasting, and research.

Upper air data across the world is combined with surface observations and a series of equations to create weather models for short term and long term weather forecasting.

Upper air balloons (pictured top left) are sent up twice a day and are sometimes sent up at additional times during the day during inclement weather events. Balloons are filled with a light gas, such as hydrogen or helium, so it can rise in the atmosphere.




Upper air balloons carry radiosondes, (pictured bottom left) which are instruments that have sensors to collect pressure, temperature, and relative humidity. They also collect wind speeds and directions, by tracking the position of the radiosonde through GPS detection.

Radiosondes are battery powered and have a radio transmitter attached to send the measurements through radio frequency to collect the data. The data are archived and plotted on a sounding (pictured middle left). Soundings make it easier for forecasters to visualize and analyze the data.

Upper air balloon flights usually lasts for about 2 hours and can reach above 100,000 feet before the balloon pops and the radiosonde returns back to the ground by way of parachute.

There are 92 upper air stations across the U.S. alone. This does not count for upper air stations across the world and over water. Upper air balloons are launched simultaneously so we can have consistent data of the Earth's atmosphere.

Forecasters at the LMRFC analyze soundings to determine the potential of precipitation, type of precipitation expected, and how much precipitation will occur. LMRFC forecasters also use weather models to help forecast how much precipitation will occur and input that data into the hydrologic models to see the precipitation will affect river levels.

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## Day 5


Next up, we are covering river gauges! River gauges are an essential tool to the Lower Mississippi River Forecast Center as they are used all day, every day! If you would like to learn more about river gauges, check out the graphic below! And, if you would like access river gauge data, we have provided some very helpful resources just for you!

You can check out river gauge data with the following resources:

USGS: <http://www.usgs.gov/water/>

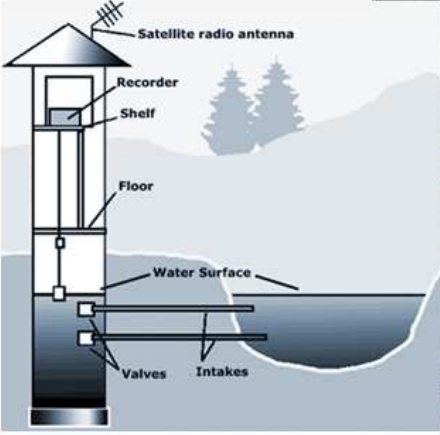
USACE: <http://www.iwr.usace.army.mil/>


LMRFC: <http://www.srh.noaa.gov/lmrfc/>



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### River Gauges








River gauges, also known as streamgages, measure the river level, or stage, in feet. There are different types of river gauges including ALERT (Automated Local Evaluation in Real-Time) gauges, staff gauges, and wire weight gauges. There are thousands of gaging stations across the U.S.

Most river gauges are automatic gauges, which means they transmit river level measurements instantaneously to the owner/operator through satellite. This is extremely beneficial in river forecasting operations. River gauge data are collected in a variety of time increments, including 5 minutes, 15 minutes, 1 hour, and 24 hours.

They can also be staff gauges, which means the gauge is manually read by an individual and is reported. This usually occurs once a day or during high flow events. Once the river stage is transmitted, it is converted to a discharge based on another tool called a Rating Curve. A rating curve is a graph showing the relationship between stage height and discharge at a given location.

River gauges are used for many different reasons including real-time data for forecasting, historical data for research, water management, and navigation purposes. Most of the river gauges in the LMRFC area owned and operated by the USGS and the U.S. Army Corps of Engineers. Most river gauge data are available on the internet for the public to access

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## Day 6

We just talked all about river gauges and their importance in the LMRFC's operations; and, now, it's time to highlight a tool that uses river gauge data...it's the hydrograph! Check out the graphic below to learn more about hydrographs and how the LMRFC uses them on a daily basis.

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## Lower Mississippi River Forecast Center

## Hydrographs

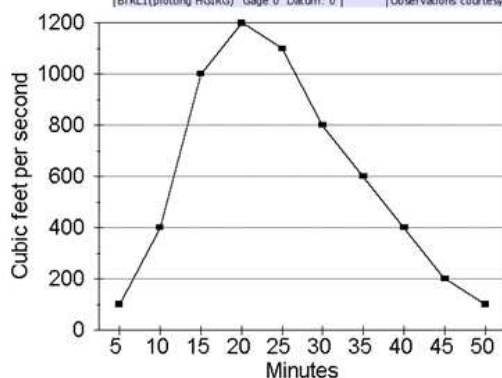
A hydrograph is a graph that shows the change in river stage (level) or discharge (rate of flow) over time at a specific location. The river stage (level) is measured in feet, and the river discharge (rate of flow) is typically measured in cubic feet per second.

Hydrographs are an easy way to view current river conditions, as well as visualize what the river is going to do based on precipitation, runoff, soil moisture parameters, and routed water from upstream. The figures to the left show two different types of hydrographs. The top hydrograph depicts a stage hydrograph for a location, while the bottom hydrograph shows a discharge hydrograph.

There are 3 distinctive part of a hydrograph: the rising limb, the crest, and the recession limb. The rising limb is when the river is rising and the stage/discharge is increasing with time across the graph. The recession limb is when the river is receding, and the stage/discharge are decreasing with time. Lastly, the crest is the peak stage/discharge at that one location. On the MS River, the peak stage and discharge can vary by several days due to hydraulic processes.

The LMRFC uses hydrographs on a daily basis to display river stages to the public. Real-time hydrographs are available on the LMRFC's webpage here:

<http://www.srh.noaa.gov/lmrfc/>.



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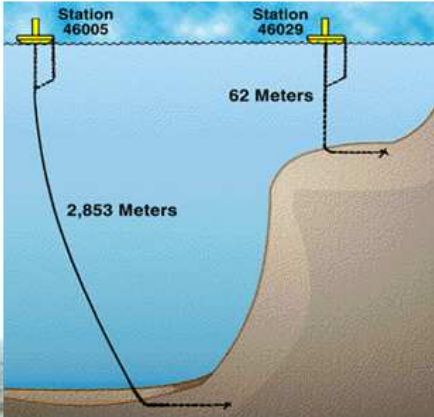
## Day 7


Are you ready for another LMRFC tool?!? Here ya go... covering buoys! If you would like learn more about buoys and their role with the LMRFC and the National Weather Service, check out the graphic below!


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## Lower Mississippi River Forecast Center

### Buoys







Buoys are floating devices that are used for many different purposes ranging from collecting useful data to serving as navigation or marking devices over water.




They can be moored buoys, which are stationary buoys that are anchored to the sea floor by cables, chains, or ropes (pictured top left). Or, they can be drifting buoys, which are allowed to drift with the waves (pictured bottom left).

There are many types of buoys that have instruments attached to measure different parameters. Buoys that are used to measure weather and ocean parameters are the most useful to the LMRFC. These buoys include tsunami buoys and weather buoys.

Tsunami buoys are anchored buoys which detect changes in water pressure. Weather buoys are like weather stations over water. They measure atmospheric temperature and pressure, and wind speeds and directions. Some weather and tsunami buoys also measure water temperatures, wave heights and periods, and ocean currents. Buoys usually report measurements via satellite feeds.

Buoys serve a vital role in the NWS with a variety of purposes. Buoys help meteorologists study teleconnection patterns, including El Niño. They are also important in studying, forecasting, and tracking tropical cyclones. Lastly, buoys are important for coastal NWS offices and centers with tide predictions for marine and river forecasts.

A large number of buoys used by the NWS are in a network of buoys owned and operated by the National Data and Buoy Center. You can check out their website here: <http://www.ndbc.noaa.gov/>. Some buoys even have cameras on them to see wave heights, as well as detect vandalism by nearby vessels.

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## Day 8

We're still going with our 5<sup>th</sup> monthly module! And, next up, we have a special tool just for you...it's the satellite! If you want to learn all about satellites and how they play a role in the LMRFC's operations, check out the graphic below.



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### Satellites





Satellites are artificial objects placed in space to collect data and provide communication (pictured top left). Satellites serve many purposes in communication, observations, navigation, research, and weather forecasting. Thousands of satellites have been launched over the past 50 years and many still remain in orbit today.

The purpose of satellites for the NWS is to obtain data from space to monitor the Earth and its meteorological phenomenon. Satellites are used on a daily basis at the LMRFC for many reasons. First, we use satellite images (pictured bottom left) to help in precipitation forecasting. There are different types of satellite images that the NWS uses to view the current state of the atmosphere. These satellite images include Visible, Infrared, and Water Vapor satellite images. These satellite images are products of using different channels and sensors on satellites. The purpose of the different satellite images is to depict the current atmospheric conditions in different ways to aid in weather analysis and forecasting.

Satellites provide images of the Earth, but they also serve another vital purpose as a data collection system. The LMRFC uses satellites to collect timely river and rain gauge data for river forecasting purposes. Satellites relay data via transmitters to share data between offices and the field. These data are ingested into our hydrologic and hydraulic models for the LMRFC forecasters to issue accurate river forecasts based on current observations.

The primary satellites that the NWS uses come from NOAA's geostationary satellites and polar-orbiting satellites. The NOAA's geostationary satellites monitor the Western Hemisphere at about 22,240 miles above Earth and the polar-orbiting satellites circle the Earth and provide global information from nearly 540 miles above Earth.

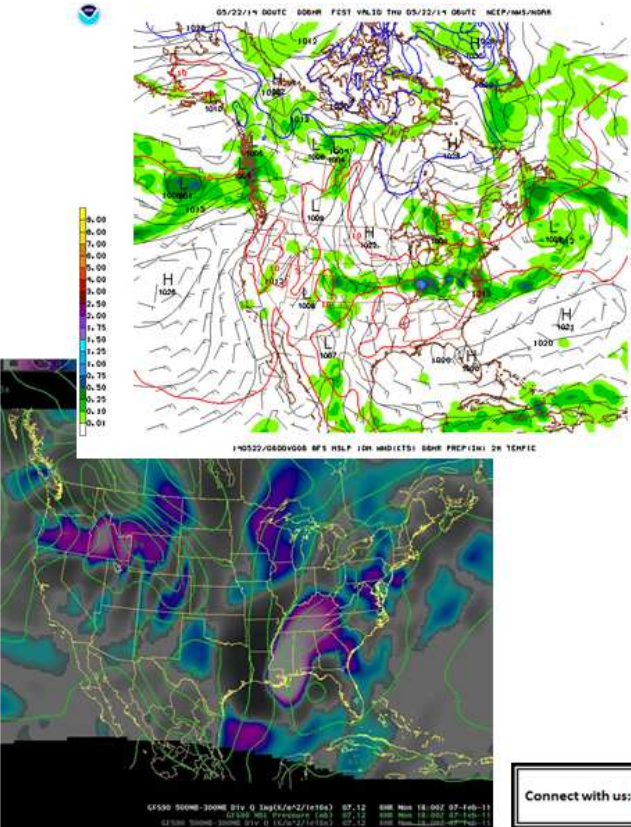
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## Day 9

It's Day 9 and we have a really neat tool in store for you...it's our models! Yup, we are talking all about our weather, hydrologic, and hydraulic models that we use on a daily basis! Models are very useful in our daily forecasts; however, it is important to remember that models are not perfect. That is why it is crucial to have the forecaster's expertise analyzing the model data and using his or her judgment in the final forecasts. If you would like to learn ALL about our models, check out the graphics below.




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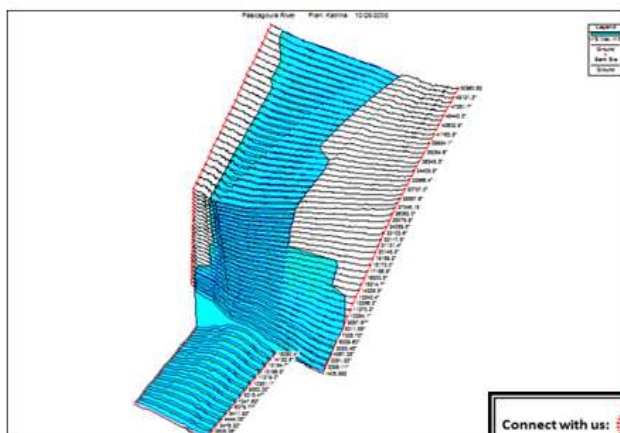
### Weather Models

- The purpose of weather models is to help in numerical weather prediction by using mathematical equations on current atmospheric and oceanic data to predict the weather. Global and regional models are run across the world multiple times a day.
- Data comes from ground observations, satellites, and upper air balloons (which we have previously discussed). These mathematical models can be used for short term weather forecasting or long term climate predictions.
- Weather models require very powerful supercomputers, and the forecasting skill of a weather model usually extends up to 10 days. However, models are only as good as the quality of the data in them.
- Weather models output a variety of weather elements including temperature, precipitation, wind, and pressure, along with many other elements that are used in weather analysis and forecasting.
- Examples of weather models include the North American Model (NAM), the European Center for Medium Range Weather Forecasting (ECMWF) model, the Global Forecast System (GFS) model, the Weather Research and Forecasting (WRF) model, the Canadian Meteorological Center (CMC) model, and the High-Resolution Rapid Refresh (HRRR) model.

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## Hydrologic and Hydraulic Models

Hydrologic and hydraulic models are used to model a variety of hydrologic processes including groundwater, surface water, and sediments. The LMRFC's models focus primarily on surface water modelling.

Hydrologic and hydraulic models are both used at the LMRFC to model surface water contributions; however, there are some big differences between these two types of models.

Hydrologic models account for the physical processes at a particular location such as rainfall, runoff, and groundwater contributions (pictured top left). Then, separate components, such as unit hydrographs and the Lag-K method, are used to route water from point A to point B. Hydraulic models use complex equations, boundary conditions, and cross sections (pictured bottom left) to account for complex routing techniques to route water from point A to point B.

Because river basins in the LMRFC area are different, we use hydrologic models for some of our river basins and hydraulic models for other river basins. An example of a hydrologic model is the Sacramento Soil Moisture Accounting (SAC-SMA) model, which is used in most of our river basins across the LMRFC. An example of a hydraulic model is the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model, which is used on the Mississippi River to account for its complexity.

The output data from these models are visualized by using hydrographs. The LMRFC uses a complex computer system that displays these hydrographs, as well as real-time data, so the forecaster can visualize the data while forecasting. This system is called the Community Hydrologic Prediction System (CHPS). CHPS allows the forecaster to not only visualize the model output, but also use local expertise to make changes to the model output as well.

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<http://www.srh.noaa.gov/lmrfc>



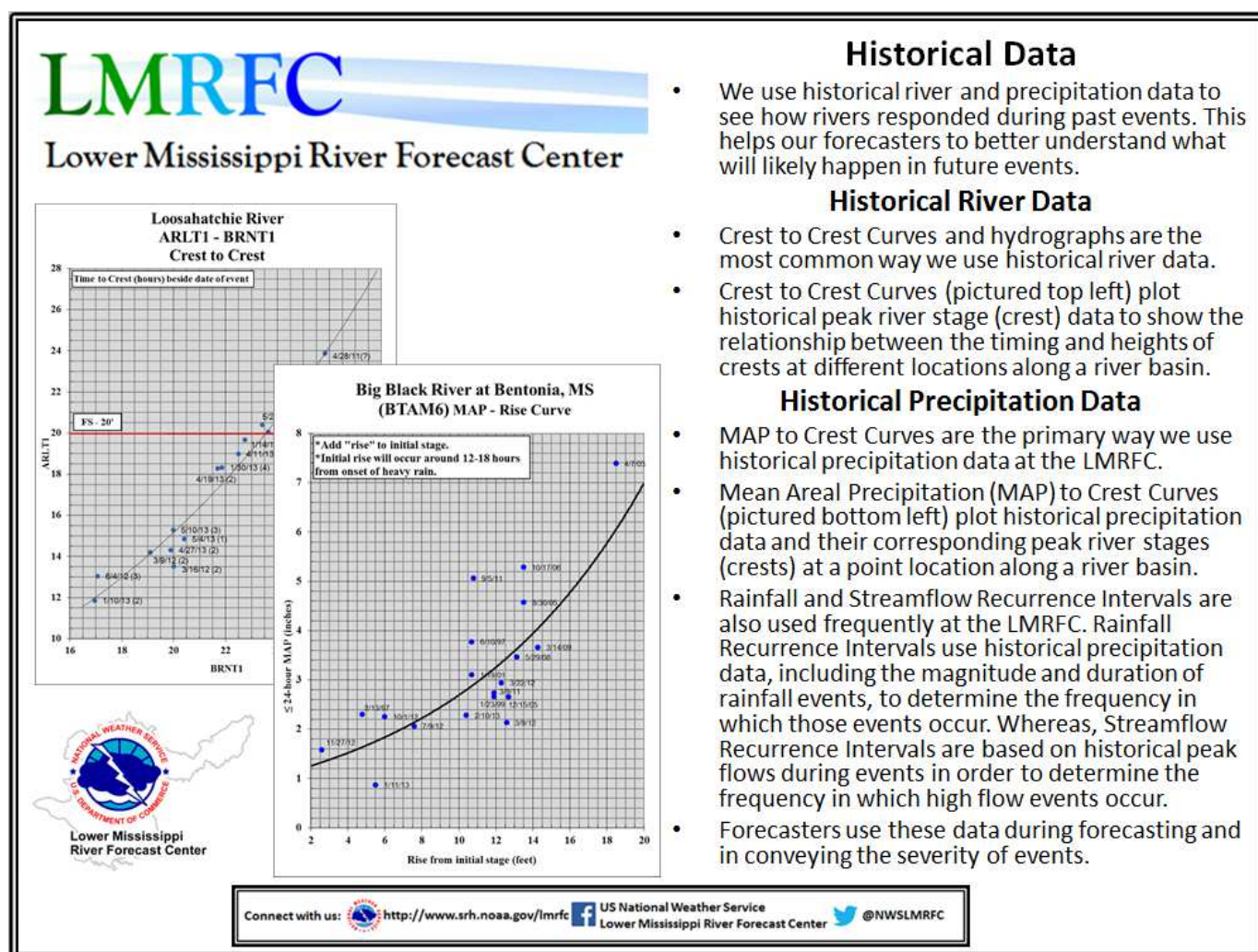
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## Day 10

We have saved one of our best tools for last. That's right; we are talking all about our historical data tools. When forecasting, especially high impact events, it is critical for forecasters to know and understand how a river basin has responded in the past. This aids in forecasting, especially when issuing critical river forecasts. To learn more about some of the historical data tools that we use often, check out the graphic below.



We hope you have enjoyed learning all about the LMRFC's key forecasting tools that we use on a daily basis. Be sure to check out our other monthly modules to learn more about the Lower Mississippi River Forecast Center and hydrology!